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German cockroach nymph (left), adult male (center) and adult female with egg case. *U.S. Department of Agriculture*

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Foreword

German cockroaches are becoming increasingly difficult to control in urban areas in Connecticut. A survey taken in January 1970 in six public housing projects in New Haven revealed that 60% of the apartments were infested. The author, therefore, has undertaken the task of attempting to develop effective, safe, and relatively inexpensive methods which will provide long-lasting control of this pest in cities.

As of January 1, 1971, materials mentioned in this bulletin that have been registered for use in controlling German cockroaches are as follows: Boric acid powder; Lethalair® aerosol bomb (V-23 formula) containing 0.5% pyrethrins and 1.0% piperonyl butoxide.

The following materials are registered for use in controlling German cockroaches by qualified pest control operators only: Baygon® spray concentrate; Baygon® 2% roach bait insecticide, Diazinon® 4E.

The following materials are not registered for use in controlling German cockroaches in dwelling units. They may or may not be registered subsequently for this use: No-Pest® Insecticide Ministrip (20% dichlorvos); Cab-O-Sil® M5.

Chemical Control of German Cockroaches in Urban Apartments

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Introduction

The German cockroach, *Blattella germanica*, is found throughout the United States in all types of buildings. The National Pest Control Association (NPCA, 1965) considers it the most important household pest in this country. It is becoming increasingly difficult to control this cockroach, especially in urban areas in this state and elsewhere. Rapid reproduction rates, adaptability, repellency, and development of insecticidal resistance all contribute to the difficulties experienced in controlling cockroaches. Accessibility, costs, and sanitation are also major obstacles to effective control.

The control method in general use today in the inner-city environment consists of applying residual insecticidal sprays to out-of-the-way areas normally used as harborage and breeding places by the roaches. Sprays are also placed along routes of travel such as baseboards, ceiling moldings, and pipes. Monthly and sometimes weekly treatments are applied because of the relatively short residual life of some of the liquid insecticidal sprays commonly used. Many apartment units are treated on a complaint basis, but most are not treated at all. Thus some roaches are never exposed to an insecticide, while others move from treated areas to untreated areas. These roaches serve as a continuing source of infestation. The complaint method usually reduces roaches in the units treated but does not provide effective, long-lasting reduction of cockroaches.

The efficiency of the "complaint method" of treating, whereby the decision of whether or not to treat an apartment is made by the tenant, is illustrated in part by the results obtained in a recent survey of public housing in New Haven. This survey for roaches conducted in January 1970 showed that 60% of the 2,100 units surveyed were infested with the German cockroach, even though free pest control service was available to the tenants for several years. In one of the projects surveyed, 80% of the units had roaches and almost 30% of these units had infestations which were classified as very heavy.

Field trials were initiated in 1968-69 to evaluate various chemical methods of controlling cockroaches in public housing in the New Haven area. My purpose is the development of a safe, acceptable, and relatively inexpensive method which will provide control of German cockroaches for a minimum of 3 months following the initial treatment.

Description and Development

Adult German cockroaches are about $\frac{5}{8}$ inch long and light brown in color. Nymphs have two black stripes running lengthwise on their back while the stripes on the adult can only be seen on the thorax. The female German roach, unlike most other roaches, carries her egg capsule protruding from her abdomen for about a month, and drops it a day or two before the eggs are ready to hatch. About 30 nymphs hatch from the capsule. The nymphs go through four feeding stages before reaching the adult stage. Roaches may mature in 6 to 8 weeks under ideal conditions of food, temperature, and moisture; thus enabling large numbers of these insects to build up within several months in some apartment houses.

Habits

German roaches enter dwellings in a variety of ways. Some of the more common routes of access include being brought in with cartons or bags from food stores, migrating from adjoining homes or apartments, and being transferred along with household goods when a family moves from an infested dwelling to an uninfested one.

Once in the building, roaches hide during the day in dark, sheltered places, usually close to moisture and food in kitchens, pantries, and bathrooms. They are sometimes found in furniture in livingrooms and bedrooms, and in clothes closets. They prefer to rest on wood and other rough surfaces rather than on smooth surfaces such as metal doors or cabinets. However, in heavily infested dwellings they can be found scattered throughout the building or apartment in all areas and on all surfaces. According to Shuyler (1956), the German cockroach has acquired the tendency in the last 10 or 15 years of infesting the entire building rather than certain limited areas, to which they were formerly restricted.

The German roach is a general feeder and eats almost all kinds of food used by man. Roaches hiding in non-food areas of a dwelling can survive by feeding on scattered crumbs, soiled clothing, or glue. Miesch (1964) found that a semi-solid bait of dehydrated potatoes, sucrose, and water was the most attractive to this roach. They normally feed in a limited area of a building, depending on the sense of taste more than the sense of smell in locating food. For this reason baits used to control the German cockroach must be scattered in many areas through a building.

Materials and Methods

Various chemicals were evaluated against German cockroaches in urban apartments in the greater New Haven area. All apartments within a given building were treated. For sociological reasons, untreated check apartments were not utilized. Instead, specific treatments were compared with each other.

Treatments combining a dust or bait with a spray are shown in Table 1. The first treatment consisted of dusting with technical boric acid

Table 1. Effectiveness of combination treatments in reducing German cockroach infestations in urban apartments

Treatment	No. of Apts.	Initial No. Cockroaches	No. Cockroaches After	
			1 Month	3 Months
I. Boric acid — 0.5% pyrethrins + 1.0% piperonyl butoxide (p.b.)	4 2	+50 3-4	1 0	1-5 0-2
II. Boric acid + 0.02% Cab-O-Sil M5 — 0.5% pyrethrins + 1.0% p.b.	4 3	+50 6-13	0-5 0-4	0-1 0-3
III. Boric acid — 1.1% Baygon	1 3	+50 3-33	1 0-1	37 0-3
IV. Boric acid + 0.02% Cab-O-Sil M5 — 1.1% Baygon	1 2	+50 5-15	12 0-1	0 1
V. Baygon 2% roach bait — 1.1% Baygon	4 4	+50 6-26	0-1 0	0-+50 0

powder which had been screened through a flour sifter, followed by spraying with an aerosol bomb containing a petroleum base solution of 0.5% pyrethrins and 1.0% technical piperonyl butoxide (Lethalair® V-23). A submicroscopic silica, 0.02% Cab-O-Sil® M5, was added to screened boric acid powder as an anti-caking agent in the second treatment and followed by the pyrethrum-piperonyl butoxide aerosol spray. Components of the third treatment included boric acid powder and a 1.1% Baygon® spray. The fourth treatment was similar to the third with the exception that Cab-O-Sil was added to the boric acid powder. Baygon 2% roach bait insecticide was used, followed by the 1.1% Baygon spray in the final treatment.

Apartments in buildings which had no infestations at the onset of this study were treated with boric acid powder alone to insure that roaches would not find a safe sanctuary in the building.

Boric acid dusts and Baygon bait were applied at the rate of approximately $\frac{1}{4}$ pound per apartment using a Getz gun (Figure 1). The Baygon roach bait was formulated as "crevice-sized" particles which could easily be applied using dusting techniques. The dust or bait should be lightly applied to many areas so that large amounts of the material will not accumulate in a particular spot. Areas treated included under and behind stoves, refrigerators, and other appliances; under radiators; in corners of cabinet, pantry, and closet shelves, in sink cabinets; and other cracks, voids, and enclosed areas into which dust could be blown. Particular attention was given to dusting false areas in and under kitchen cabinets, because they provide excellent harborage for these roaches.

Pyrethrum-piperonyl butoxide aerosol was directed into areas such as under sinks, above and between shelves of cabinets and closets, around toilets, radiators and appliances, on baseboards and ceiling moldings and in other areas where dust would not adhere or was unsightly (Figure 2). In apartments with heavy infestations, all doors and windows were closed and the aerosol was space-sprayed in bathroom, kitchen, and pantry areas and allowed to remain for 15 minutes before ventilating the area. Tenants were asked to remain outdoors until the ventilation was completed when



Figure 1. Applying dust or bait, using a hand duster.



Figure 2. Applying pyrethrin aerosol with a 5-lb. bomb.

Table 2. Effectiveness of dichlorvos resin strips in reducing German cockroach infestations in urban apartments

No. of Apartments	Initial No. Cockroaches	First Treatment	No. Cockroaches 3 months after 1st treatment	Second Treatment	No. Cockroaches 3 months after 2nd treatment
Building A					
2	+50	22-42 dichlorvos* strips	1-5	10 dichlorvos strips	0-2
2	5-9	10 dichlorvos strips	0-1	5-8 dichlorvos strips	0
Building B					
3	+50	diazinon**	+50	38-40 dichlorvos strips	0-1
3	8-17	diazinon	1-3	6-16 dichlorvos strips	0

* 20% dichlorvos

** initial spray of 1.0% diazinon followed by 2 applications of 0.5% at one month intervals.

this type of treatment was used. When the 1.1% Baygon spray was used approximately $\frac{1}{4}$ pint of a water base spray was applied per apartment, with a $\frac{1}{2}$ gallon compression sprayer.

Field tests were also undertaken to evaluate dichlorvos resin strips with diazinon spray for controlling German cockroaches (Table 2). Diazinon® 4E water base spray was applied to all areas normally "inhabited" by the roaches with a $\frac{1}{2}$ gallon compression sprayer. An initial spray containing 1.0% diazinon was followed by two applications of 0.5% at one month intervals. The resin strips used were 2-inch No-Pest® insecticide ministrips containing 20% dichlorvos and were encased in a protective plastic container. The ministrips were placed under or behind appliances and infested furniture; under sinks and radiators; on cabinets, pantry and closet shelves, and along the ceiling molding. The area (cubic feet) of the apartments was calculated and the approximate rate of one strip per 100 cubic feet was used in heavily infested apartments and one strip per 200 cubic feet in the remaining ones. Strips were left in the apartments for 3 months after which they were removed and replaced with new strips at a lower rate.

Treatments were evaluated using a pyrethrin aerosol spray to flush cockroaches from potential resting areas and comparing the numbers flushed immediately before treatment with those flushed at one month intervals after treatment. Infestations were classified as none (0), low (1-3), moderate (4-9), high (10-49), and very high (+50).

Results and Discussion

Dusting and Spray Combination Treatments. Two public housing buildings of similar construction with 11 and 13 apartments per building, in New Haven public housing, as well as 6 smaller apartment houses were used for the combination treatment tests. The majority of apartments were treated only once; several of the very heavily infested apartments required supplementary treatments in some areas 1 week after the initial treatment.

Apartments in buildings with no infestation initially were treated with boric acid powder only and remained uninfested during these tests. As shown in Table 1, all combination treatments reduced German cockroaches to five or less roaches flushed after 1 month in all apartments except one. In this very heavily infested apartment, which was treated with boric acid plus Cab-O-Sil and Baygon spray, roaches were found in a heating duct in the kitchen and subsequent treatment of this area with boric acid powder resulted in a complete elimination of roaches after 3 months. In those apartments treated with boric acid-pyrethrum aerosol (I), boric acid plus Cab-O-Sil-pyrethrum aerosol (II), and boric acid plus Cab-O-Sil-Baygon spray (IV), five roaches or less were found after 3 months. Boric acid or Baygon bait combined with Baygon spray reduced roaches in most of the apartments for 3 months; however, treatments were ineffective for 3 months in two of the apartments which had

very heavily initial infestations. Many roaches were flushed from under a washer in one of the apartments treated with Baygon spray and boric acid powder. The tenant had removed the boric acid powder from this area. In the other apartment which was treated with Baygon spray and bait there were more than 50 roaches flushed from a wall void around a pipe in the sink cabinet.

According to Ebeling *et al.* (1966) the effectiveness of a given insecticide is primarily dependent upon its repellency. In laboratory tests using "choice boxes," Ebeling *et al.* (1966, 1967) found that of all insecticides tested in liquid or dust formulations, as well as the common insecticide diluents, boric acid powder was the least repellent to German cockroaches. Boric acid acts mainly as a stomach poison which is ingested as the roach cleans itself. Although boric acid acts slowly in "choice box" tests, it usually resulted in 100% kill more rapidly than with more toxic insecticides because of its low repellency. Field studies also showed that boric acid alone or preceded by a pyrethrum aerosol or 1% Baygon spray, resulted in better and longer lasting control of German cockroaches than other insecticides with which it was compared (Ebeling *et al.* 1968 a, b).

Pyrethrum or Baygon spray used in combination with boric acid quickly kills many roaches. Roaches not killed by the sprays and which are repelled will be inclined to move into or through areas in which boric acid powder has been placed. The residual population of roaches is usually controlled by the persistent, low repellent boric acid dust. Failure to place and keep boric acid powder in all key areas within an apartment building will not provide satisfactory control.

Dichlorvos resin strips and diazinon spray treatments. Two similar public housing buildings with eight apartments per building were used for the dichlorvos resin strips and diazinon spray tests. The results presented in Table 2 show that in apartments in building A with moderate to very high infestations initially, the numbers of roaches flushed were reduced after 3 months treatment with dichlorvos mini-strips to zero to five in all four apartments. With the number of strips used reduced during the second 3 months, no cockroaches were flushed in three of the four apartments and two were seen in the remaining one. Apartments with no or low infestations and treated with 5 to 10 strips remained at this level during the 6 months.

In building B, which was treated initially with three monthly sprays of diazinon, the numbers of roaches were reduced to a low level in three

Table 3. Effectiveness of diazinon residue against two strains of German cockroaches confined to the deposits†

Treatment	KD ₅₀ (hours)	
	Eastview strain	Laboratory strain
0.5% diazinon	+24	2.2
1.0% diazinon	+24	1.8
Check	None	None

† Three replicates with 10 adult males per replicate.

apartments with moderate to heavy infestations (Table 2). In very heavily infested apartments there was some reduction after the initial 1% diazinon spray, however, subsequent sprays with 0.5% were not effective. As diazinon had been used in these apartments previously for roach control, it was suspected that these roaches may have developed some resistance to this insecticide. Therefore, dichlorvos strips were used in these same apartments for the remaining 3 months. As shown in Table 2 the infestation was reduced to zero to 1 roaches flushed after 3 months using the dichlorvos mini-strips.

Table 3 presents the results of laboratory tests in which German roaches collected from these apartments, Eastview strain, and a laboratory strain were confined on filter paper which had been dipped into the solution of diazinon and allowed to dry. The Eastview strain roaches were allowed to develop through one complete generation in the laboratory before testing. The time in which 50% were knocked down (KD_{50}), was greater than 24 hours for the Eastview strain as compared to 1.8 (1.0% diazinon) and 2.2 (0.5% diazinon) hours for the laboratory strain, indicating the Eastview roaches had developed some resistance to diazinon. Spraying with 0.5% diazinon instead of 1.0% during the last two treatments may have contributed to the lack of control in the heavily infested apartments.

Field tests conducted by Russell and Frishman (1965) using 10-inch dichlorvos resin strips at the rate of $1\frac{1}{2}$ strips per 1000 cubic feet produced 100% mortality in German roaches after 48 hours in unventilated areas such as closed bathrooms. Higher dosages, however, did not kill all roaches in well ventilated rooms during the same period of time. Placement of 2-inch strips in sink cabinets resulted in an average mortality of 67% for females and 77% for males after 48 hours.

The successful control obtained in the two buildings treated in this study (Table 2) may be due to the placement of mini-strips in a number of enclosed areas within a room, such as in cabinets and under appliances, as well as exposure to the insecticide over the 3 month period. Placing dichlorvos mini-strips in an apartment was also less objectionable to tenants than spraying or dusting. Tenants also reported that the strips were odorless and had no adverse effects on pets in their apartments.

Summary

Boric acid-pyrethrum aerosol and pyrethrum or Baygon spray combined with boric acid plus Cab-O-Sil controlled roaches in all apartments treated for 3 months. Combination treatments of boric acid-Baygon spray and Baygon bait-Baygon spray controlled German cockroaches in all apartments treated for one month and in most of the apartments for 3 months. Dichlorvos mini-strips controlled this roach after 3 months use in apartments treated. Diazinon controlled roaches in all but very heavily infested apartments. Resistance to diazinon was found in this roach population.

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